

**LICHEN BIOMONITORING PROGRAM
AND AIR QUALITY BASELINE**

**IN SELECTED SITES OF THE BRIDGER WILDERNESS AREA,
BRIDGER-TETON NATIONAL FOREST**

FINAL REPORT

SUBMITTED BY

**LARRY L. ST. CLAIR, Ph.D.
ASSOCIATE PROFESSOR OF BOTANY AND CURATOR OF
NON-VASCULAR CRYPTOGRAMS
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH 84602
AND
CLAYTON C. NEWBERRY, RESEARCH ASSOCIATE
DEPARTMENT OF INTEGRATIVE BIOLOGY
UNIVERSITY OF CALIFORNIA, BERKLEY, CALIFORNIA 94720**

10 DECEMBER 1993

INTRODUCTION

Project Objectives:

1. Establish a lichen biomonitoring program and baseline by setting up 6-8 reference sites within the Bridger Wilderness Area. Final selection of reference sites was made in consultation with Forest Service personnel.
2. Collect, curate and identify lichen species from each reference site in the Bridger Wilderness Area.
3. Identify and collect pollution-sensitive lichen species for elemental analyses from each reference site in Bridger Wilderness Area.
4. Determine baseline thallus concentrations of sulfur and one or two additional pollutants, using ten replicate samples of one documented pollution sensitive species from each reference site. [This objective was changed. Samples of pollution sensitive lichen species (a minimum of one per reference site) have been analyzed using PIXE analysis (Proton-Induced X-ray Emission analysis) for multiple elements.]
5. Prepare and submit a draft report by 31 January 1992.
6. Prepare and submit the final report detailing the results of this study by 1 July 1993 (*the deadline for the final report was adjusted due to constraints associated with upgraded elemental analysis techniques*). The final report will include:
 - a. a map showing the location of each reference site along with a brief habitat description of each reference site;
 - b. a preliminary list of lichen species from each reference site with relative abundance, growth form, and substrate data for each species;
 - c. a list of pollution-sensitive or potentially pollution-sensitive lichen species for each reference site;
 - d. color photographs/slides of several lichen species from the Bridger Wilderness Area known or suspected to be sensitive to specific air pollutants;
 - e. baseline thallus concentrations of sulfur and other pollutant elements for one sensitive indicator species from each reference site;
 - f. a list of references, protocols, equipment and supplies used during the course of this study; and
 - g. other pertinent information or unusual observations.

Lichens as Biological Indicators of Air Quality:

Protocol for using lichens as bioindicators of air quality is well-documented (Fields & St. Clair 1984; St. Clair 1989; Richardson 1992). Hale (1983) noted that lichens have been used in three basic ways to monitor the effects of air pollution on biological systems: 1) elemental analysis of lichen tissues, 2) mapping of all (or selected) lichen species found in areas adjacent to pollution sources, and 3) transplant studies. Currently, the most common approach involves a floristic survey along with elemental analyses of tissues from selected indicator species (St. Clair 1989; Wetmore 1989).

As lichens accumulate many different pollutants from atmospheric outwash, lichen tissues provide a record of the kinds and relative quantities of air pollutants in any particular airshed (Schutte 1977; Wetmore 1989; Rope and Pearson 1990). Pollutant accumulation patterns for specific elements have been monitored over time by correlating thallus growth rates and pollutant concentrations in excised portions of lichen thalli (Lawrey & Hale 1981). Changes in lichen physiological processes indicate pollution-related damage long before other, more easily detectable changes in thallus color, morphology, or community structure become apparent (Fields & St. Clair 1984).

Lists of pollution-sensitive lichen species have commonly been published in conjunction with floristic and ecological surveys (Rushforth et al. 1982; Wetmore 1989). As certain lichen species are inherently more sensitive to airborne contaminants, air quality can be effectively monitored by occasionally reevaluating lichen community and/or physiological parameters. Pollution-related changes can then be documented by comparing followup data to original baseline data.

Previous Lichen Biomonitoring Studies In The Bridger Wilderness Area:

In 1983 Mason Hale conducted a preliminary survey of the lichens of Bridger Wilderness Area. The principal goal of Hale's work was "to find what lichens are suitable for use as pollution monitors and to establish baseline values for important elements". Hale set up a total of three permanent photographic plots. These plots were located: 1) in a large granitic outcrop west of the main camping area near the north end of Lake Ethel, 2) on an open granite ledge in a ravine southeast of Lake Vera, and 3) in a large talus slope southwest of Big Sandy Lake. Hale established one photographic plot at each of the study sites and briefly characterized the lichen species in each plot. He also collected sufficient material of five lichen species from various parts of the wilderness to perform elemental analysis. Four of the species were collected from rock substrates [*Xanthoparmelia cumberlandia*, *Xanthoparmelia taractica*, (in 1991 Hale monographed the genus *Xanthoparmelia* and concluded that specimens identified in the past as *X. taractica* are more appropriately identified as *X. coloradoensis*), *Xanthoria elegans*, and *Lecanora novomexicana*]; and one species was collected from bark/lignum substrates (*Letharia vulpina*). Three of the sensitive indicator species have the foliose growth form (*Xanthoparmelia cumberlandia*, *Xanthoparmelia coloradoensis* and *Xanthoria elegans*), one was crustose (*Lecanora*

novomexicana) and one was fruticose (*Letharia vulpina*).

Hale concluded from the elemental analysis data that lead values for *X. cumberlandia* at higher elevations were 2 to 3 times higher than Rocky Mountain background levels. He further concluded that values for Zn and Mn were also elevated. These data led Hale to conclude that some pollutant accumulation, beyond normal background levels, was occurring.

General Habitat Description For The Bridger Wilderness Area:

The Bridger Wilderness Area is located in west-central Wyoming and encompasses most of the Wind River Mountains. The Wind River Range contains fifteen peaks over 12,000 feet including Wyoming's highest point Gannett Peak (13,804 feet). The Wind River Range is more than 100 miles long and about 40 mile wide in contrast to the wilderness area which is 90 miles long and about 15 miles wide at its widest point. The Wind River Mountains are a coherent block of Precambrian crust bound on the southwest by one of the largest thrust faults in the Rocky Mountains. Between 55 and 60 million years ago (during the Laramide orogeny) the Wind Rivers were lifted up and thrust over 13 miles to the southwest over the sedimentary deposits of the Green River Basin. During the last two million years the mountains and basins of the range have been continually eroded by stream action; and have experienced extensive glaciation on at least three separate occasions.

The vascular plant vegetation of Bridger Wilderness Area is dominated by a variety of conifers including, *Juniperus communis* var. *depressa*, *Juniperus scopulorum*, *Abies lasiocarpa*, *Picea engelmannii*, *Picea pungens*, *Pinus flexilis*, *Pinus albicaulis*, *Pinus contorta*, and *Pseudotsuga menziesii*. The understory vegetation is often dominated by various species of blueberries and huckleberries including, *Vaccinium occidentale*, *Vaccinium scoparium* and *Vaccinium membranaceum*. Other common understory plants include *Mahonia repens* and *Paxistima myrsinites*. There is also some development of mixed conifer-Quaking aspen communities in the wilderness.

Lichen Biomonitoring Reference Sites In The Bridger Wilderness Area:

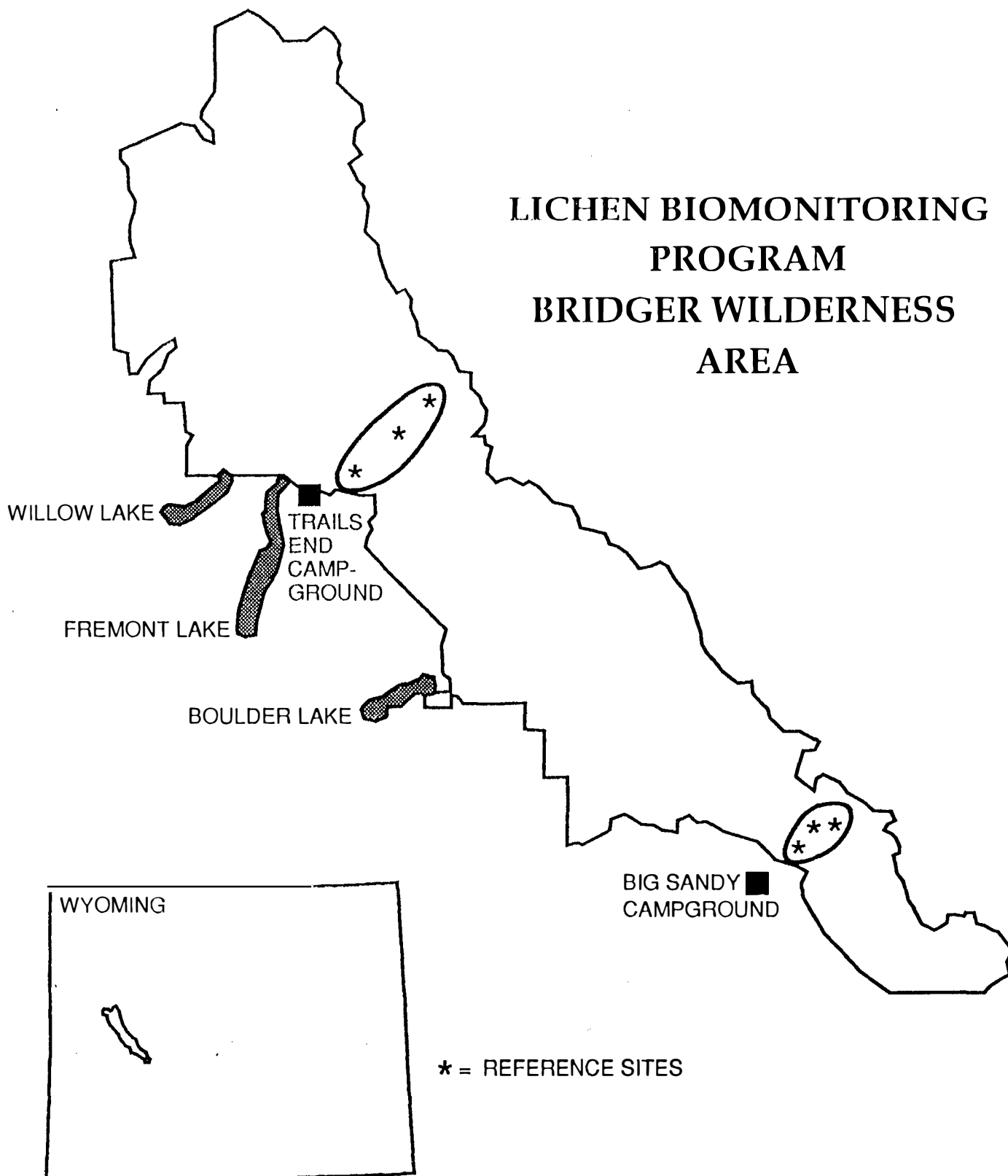
A total of 6 reference sites were set up in two general areas of the wilderness (figure 1). Three reference sites were established between the Trail's End Campground Trailhead and Seneca Lake; and three reference sites were established between the Big Sandy Campground Trailhead and Deep Lake. Specifically, reference sites were established along the trail to Hobb's Lake, at Hobb's Lake, at Seneca Lake, along the trail to Big Sandy Lake, at Big Sandy Lake, and along the trail between Big Sandy Lake and Deep Lake.

The general location of each reference site was determined in consultation with Forest Service personnel. All available habitats and substrates at each reference site were carefully examined. Collections representing as many different species of lichens as possible were made at each reference site.

BRIDGER WILDERNESS AREA

TETON-BRIDGER NATIONAL FOREST

lichen biomonitoring program bridger wilderness area



METHODS

Collection, Curation, Identification, and Deposition of Lichen Specimens:

Because lichen distribution is directly influenced by substrate, moisture and sunlight, all available substrates and habitats at each reference site were carefully examined. Small amounts of each lichen species were either removed directly from the substrate, or depending on the species, with a small piece of the substrate (bark, wood, soil or rock).

All specimens were placed in carefully labeled paper sacks and taken back to the BYU Herbarium of Nonvascular Cryptogams, where they were curated, identified, placed in permanent herbarium packets, and labeled with the current epithets and authors' names as well as detailed information about the collection site, habitat and substrate. Herbarium numbers (BRY C-) were also assigned.

Species were identified using standard lichen keys and taxonomic treatises. Standard chemical spot tests and, where necessary, thin-layer chromatography techniques were also used to finalize species identifications.

One set of specimens collected from each reference site will be permanently housed at the the BYU Herbarium of Nonvascular Plants in Provo, Utah. At the request of the Forest Service a voucher set of specimens will be sent to the University of Wyoming Herbarium in Laramie.

Collection of Lichen Thalli for Laboratory Analyses:

After careful consideration of species abundance, substrate, growth form, documented/suspected pollution sensitivity and general distribution patterns of the lichens at each reference site, one species was designated as the sensitive, indicator species and used for all laboratory chemical analyses.

At each reference site sufficient material of at least one sensitive, indicator species was collected for laboratory analyses (5-10 grams dry weight). All lichen material collected for elemental analyses was placed in Hubco cloth bags (to avoid contamination) and transported back to the BYU Herbarium of Nonvascular Plants. Excess material is permanently stored in Hubco cloth bags in the elemental analysis collection at the BYU Herbarium of Nonvascular Plants. This material is available for additional testing upon request.

Determination of Elemental Concentrations in Lichen Tissues:

In the laboratory, surface debris and dust were removed from all samples. Clean, two gram samples of one or two indicator species from each reference site were delivered to the Elemental Analysis Laboratory at Brigham Young University.

Samples were then prepared for PIXE analysis using the methods of Duflou et al. (1987). Lichen samples were placed in Teflon containers with a Teflon coated steel ball, cooled to liquid nitrogen temperature, powdered by brittle fracture using a Braun Mikro-Dismemberator II, and then dried in an Imperial IV Microprocessor Oven for 14 hours at 80° C. Subsamples weighing 150 mg were

then weighed into teflon containers and spiked with 1.00 ml of a 360 ppm yttrium solution. The samples were then oven dried again for 14 hours at 80° C. Samples were then homogenized again using the microdismemberator. Approximately 1 mg of the powdered lichen was then carefully weighed onto a thin polycarbonate film in an area of 0.5 cm². A 1.5% solution of polystyrene in toluene was used to secure the sample to the film.

Samples were analyzed using a 2 MV Van De Graaff accelerator with a 2.28 MeV proton beam which passed through a 1.1 mg/cm² pyrolytic graphite diffuser foil. The proton beam was collimated to irradiate an area of 0.38 cm² on the sample. Typically, 10-100 nA proton beam currents were used. X-rays were detected using a Tracor x-ray spectrometer, model TX-3/48-206, with a 10 mm² by a 3 mm thick Si(Li) detector positioned at 90° to the proton beam. Samples were analyzed twice using different x-ray absorbers between the sample and the detector. One was a 49 mg/cm² Mylar absorber with a pinhole of 0.27 mm² area (2.8% of detector area). The Mylar was backed with 8.5 mg/cm² beryllium foil. A 98 mg/cm² Mylar absorber was also used.

To insure adequate quality control, samples of NIST SRM 1571, orchard leaves, and other standards were also prepared and analyzed using the same procedures.

RESULTS AND RECOMMENDATIONS

Lichen Material Collected for Elemental Analyses:

A total of 14 samples including 5 species from two substrates were collected for elemental analyses. Analyses have been performed on seven of the samples using Proton Induced X-ray Emission (PIXE) techniques. Below is a list of the elemental analysis samples by sample number, species, substrate and collection site (the first number represents the storage drawer and the second number represents the bag number). All specimens are stored in Hubco cloth bags in the elemental analysis collection in the Herbarium of Nonvascular Cryptogams at Brigham Young University.

Sample #	Taxa	Substrate	Collection site
1-1	<i>Dermatocarpon miniatum</i>	Rock	Trail to Big Sandy Lake
1-2	<i>Dermatocarpon miniatum</i>	Rock	Trail to Big Sandy Lake
1-3	<i>Umbilicaria vellea</i>	Rock	Big Sandy Lake
3 ✓ 1-4	<i>Xanthoparmelia cumberlandia</i>	Rock	Hobb's Lake
1-5	<i>Umbilicaria vellea</i>	Rock	Hobb's Lake
3 ✓ 1-6	<i>Letharia vulpina</i>	Pine lignum	Hobb's Lake
• 2 1-7	<i>Letharia vulpina</i>	Pine lignum	Trail to Hobb's Lake •
• 2 2-8	<i>Xanthoparmelia cumberlandia</i>	Rock	Trail to Hobb's Lake •
✓ 3 2-9	<i>Letharia vulpina</i>	Pine lignum	Big Sandy Lake
✓ 3 2-10	<i>Rhizoplaca chrysoleuca</i>	Rock	Big Sandy Lake
• 3 2-11	<i>Xanthoparmelia cumberlandia</i>	Rock	Big Sandy Lake
• 2 2-12	<i>Xanthoparmelia cumberlandia</i>	Rock	Trail to Big Sandy Lake •

2-13 ✓ *Xanthoparmelia cumberlandia* Rock below Big Sandy Lake
 17-133 *Xanthoparmelia cumberlandia* Rock Seneca Lake
 Elemental analyses have been performed on the following samples: 1-2, 1-4, 1-5, 1-6, 2-9, 2-10, and 2-13. ✓

List of Air Pollution Sensitive Indicator Species by Reference Site:

Trail to Hobb's Lake:

Bryoria fuscescens (intermediate sensitivity to sulfur dioxide)
Cladonia fimbriata (sensitive to sulfur dioxide)
Leptochidium albociliatum (sensitive to ozone)
Letharia vulpina (some sensitivity to ozone)
Ochrolechia androgyna (sensitive to sulfur dioxide)
Parmeliopsis ambigua (intermediate sensitivity to sulfur dioxide)
Physcia dubia (sensitive to fluoride)
Pseudephebe minuscula (intermediate sensitivity to sulfur dioxide)
Rhizocarpon geographicum (sensitive to ozone)
Rhizoplaca melanopthalma (sensitive to sulfur dioxide)
Usnea hirta (sensitive to sulfur dioxide)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)
Xanthoria fallax (intermediate sensitivity to sulfur dioxide; sensitive to nitrous oxides and PAN)

Hobb's Lake

Acarospora chlorophana (sensitive to sulfur dioxide)
Parmeliopsis hyperopta (intermediate sensitivity to sulfur dioxide)
Physcia dubia (sensitive to fluoride)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)

Seneca Lake

Rhizocarpon geographicum (sensitive to ozone)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)

Trail to Big Sandy Lake

Acarospora chlorophana (sensitive to sulfur dioxide)
Bryoria fuscescens (intermediate sensitivity to sulfur dioxide)
Caloplaca holocarpa (intermediate sensitivity to sulfur dioxide)
Cladonia fimbriata (sensitive to sulfur dioxide)
Letharia vulpina (some sensitivity to ozone)
Melanelia exasperatula (intermediate sensitivity to sulfur dioxide)
Phaeophyscia sciastra (sensitive to ozone)
Physcia caesia (intermediate sensitivity to sulfur dioxide)
Physcia dubia (sensitive to fluoride)
Pseudephebe minuscula (intermediate sensitivity to sulfur dioxide)
Rhizocarpon geographicum (sensitive to ozone)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)

Xanthoria candelaria (intermediate sensitivity to sulfur dioxide;
sensitive to ozone)

Big Sandy Lake

Parmeliopsis ambigua (intermediate sensitivity to sulfur dioxide)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)

Trail between Big Sandy Lake and Deep Lake

Candelariella vitellina (intermediate sensitivity to sulfur dioxide)
Cladonia fimbriata (sensitive to sulfur dioxide)
Lecanora saligna (intermediate sensitivity to sulfur dioxide)
Letharia vulpina (some sensitivity to ozone)
Parmeliopsis ambigua (intermediate sensitivity to sulfur dioxide)
Parmeliopsis hyperopta (intermediate sensitivity to sulfur dioxide)
Peltigera canina (sensitive to ozone)
Physcia caesia (intermediate sensitivity to sulfur dioxide)
Rhizocarpon geographicum (sensitive to ozone)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Usnea hirta (intermediate sensitivity to sulfur dioxide)

Checklist of Lichen Species From the Bridger Wilderness Area:

Acarospora badiofusca (Nyl.) Th. Fr.

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22079

Acarospora chlorophana (Wahlenb. ex Ach.) Massal.

Growth form: Crustose with effigurate margin
Substrate: Rock
Site(s): Big Sandy Lake Trail; Hobb's Lake
Relative abundance: Locally common
Pollution sensitivity: Sensitive to sulfur dioxide (Hale 1982)
Comments: None
Deposition of specimens: BYU Herbarium #22080; 22276

Acarospora nitida Magn.

Growth form: Crustose with effigurate margins
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22081

Aspicilia caesiocinerea (Nyl. ex Malbr.) Arnold

Growth form: Crustose
Substrate: Rock
Site(s): Trail to Deep Lake; Trail to Hobb's Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22196 (duplicate specimen sent to University of Wyoming); 22277

Aspicilia reptans (Looman) Wetm.

Growth form: Fruticose
Substrate: Vagrant on the soil
Site(s): Big Sandy Lake Trailhead
Relative abundance: Locally abundant, but generally rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22082

Aspicilia verrucigera Hue

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22083

Bellemerea alpina (Sommerf.) Clauz. & Roux

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake; Hobb's Lake

Relative abundance: Common-abundant

Pollution sensitivity: Unknown

Comments: This is one of the most common saxicolous lichens collected in the Bridger Wilderness Area.

Deposition of specimens: BYU Herbarium #22097, 22098; 22282; 22283; 22284

Bellemerea cinereorufescens (Ach.) Clauz. & Roux

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22099; 22285

Bryonora castanea (Hepp) Poelt

Growth form: Crustose

Substrate: Moss

Site(s): Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22361a

Bryoria fuscescens (Gyelnik)

Growth form: Fruticose

Substrate: Conifer bark, twigs or lignum

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Wetmore 1987)

Comments: None

Deposition of specimens: BYU Herbarium #22100 (duplicate specimen sent to University of Wyoming); 22286

Bryoria lanestris (Ach.) Brodo & D.Hawksw.

Growth form: Fruticose
Substrate: Lignum
Site(s): Trail to Deep Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22197

Bryoria simplicior (Vainio) Brodo & D.Hawksw.

Growth form: Fruticose
Substrate: Lignum
Site(s): Trail to Deep Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22198

Buellia erubescens Arnold

Growth form: Crustose
Substrate: Lignum; decomposing lignum
Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake
Relative abundance: Common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22101 (duplicate specimen sent to University of Wyoming); 22199 (duplicate specimen sent to University of Wyoming); 22287

Buellia punctata (Hoffm.) Massal.

Growth form: Crustose
Substrate: Pine lignum
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Tolerant of sulfur dioxide (Wetmore 1987)
Comments: None
Deposition of specimens: BYU Herbarium #22102

Buellia retrovertens Tuck.

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22103

Caloplaca epithallina Lynge

Growth form: Crustose

Substrate: Epiphytic on other lichen species

Site(s): Big Sandy Lake Trail; Trail to Deep Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: This lichen grows epiphytically on other lichens; specimen #22104 was growing epiphytically on the crustose, saxicolous lichen Lecidea atrobrunnea. Specimen #22200 was growing epiphytically on the umbilicate, saxicolous lichen Rhizoplaca melanophthalma.

Deposition of specimens: BYU Herbarium #22104; 22200

Caloplaca fraudans (Th. Fr.) H. Olivier

Growth form: Crustose, scant

Substrate: Rock

Site(s): Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22301

Caloplaca holocarpa (Hoffm.) Wade

Growth form: Crustose

Substrate: Lignum

Site(s): Big Sandy Lake Trail

Relative abundance: Locally common

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Wetmore 1987)

Comments: None

Deposition of specimens: BYU Herbarium #22105 (duplicate specimen sent to University of Wyoming)

Caloplaca jungermanniae (Vahl) Th. Fr.

Growth form: Crustose

Substrate: Moss over rock

Site(s): Big Sandy Lake Trail; Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22201; 22253

Candelariella aurella (Hoffm.) Zahlbr.

Growth form: Crustose
Substrate: Lignum
Site(s): Vicinity of Big Sandy Lake; Trail to Deep Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22106; 22202 (duplicate specimen sent to University of Wyoming)

Candelariella vitellina (Hoffm) Müll. Arg.

Growth form: Crustose
Substrate: Rock
Site(s): Trail to Deep Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Wetmore 1987); sensitive to fluoride (Ryan 1990)
Comments: None
Deposition of specimens: BYU Herbarium #22203

Candelariella xanthostigma (Ach.) Lettau

Growth form: Crustose
Substrate: Lignum; among various lichen species on rock; moss
Site(s): Big Sandy Lake Trail; Vicinity of Big Sandy Lake; Trail to Deep Lake; Trail to Hobb's Lake
Relative abundance: Locally common (especially on lignum)
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium # 22107 (lignum) & 22163 (rock); 22204 (moss); 22288 (duplicate specimen sent to University of Wyoming)

Carbonea vitellinaria (Nyl.) Hertel

Growth form: Crustose
Substrate: Epiphytic
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: This species grows epiphytically on saxicolous species of the lichen genus Candelariella.
Deposition of specimens: BYU Herbarium #22108

Catapyrenium cinereum (Pers.) Körber

Growth form: Squamulose

Substrate: Soil/moss

Site(s): Trail to Hobb's Lake; Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22289 (duplicate sent to University of Wyoming); 22254 (duplicate specimen sent to University of Wyoming)

Catapyrenium daedaleum (Krempelh.) B.Stein

Growth form: Squamulose

Substrate: Soil

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22109 (duplicate specimen sent to University of Wyoming)

Catapyrenium lachneum (Ach.) R. Sant

Growth form: Squamulose

Substrate: Soil

Site(s): Big Sandy Lake Trail; Upper Seneca Lake

Relative abundance: Rare to locally common

Pollution sensitivity: unknown

Comments: None

Deposition of specimens: BYU Herbarium #22110; 22255

Cladonia bacillaris Nyl.

Growth form: Squamulose

Substrate: Lignum

Site(s): Big Sandy Lake Trail

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22111

Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel

Growth form: Squamulose
Substrate: Mossy soil
Site(s): Seneca Lake Trail
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22256

Cladonia fimbriata (L.) Fr.

Growth form: Squamulose
Substrate: Decomposing lignum; mossy soil
Site(s): Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake
Relative abundance: Common to abundant
Pollution sensitivity: Sensitive to intermediate sensitivity to sulfur dioxide (Wetmore 1987)
Comments: None
Deposition of specimens: BYU Herbarium #22112 (duplicate specimen sent to University of Wyoming); 22206 (duplicate sent to University of Wyoming); 22290 (duplicate specimen sent to University of Wyoming)

Cladonia macrophyllodes Nyl.

Growth form: Squamulose
Substrate: Soil
Site(s): Hobb's Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22291 (duplicate specimen sent to University of Wyoming)

Cladonia pocillum (Ach.) O. Rich

Growth form: Squamulose
Substrate: Soil; moss; conifer bark
Site(s): Big Sandy Lake Trail; Hobb's Lake
Relative abundance: Common to abundant
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22113 (duplicate specimen sent to University of Wyoming); 22292; 22293

Cladonia pyxidata (L.) Hoffm.

Growth form: Squamulose

Substrate: Decomposing lignum

Site(s): Big Sandy Lake Trail

Relative abundance: Locally abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22114 (duplicate specimen sent to University of Wyoming)

Cladonia sulphurina (Michaux) Fr.

Growth form: Squamulose

Substrate: Decomposing lignum

Site(s): Trail to Deep Lake

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22207 (duplicate specimen sent to University of Wyoming)

Collema crispum (Huds.) Weber *ex* Wigg.

Growth form: Foliose

Substrate: Moss over rock

Site(s): Trail to Deep Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22208

Collema fuscovirens (With.) Laundon

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22115 (duplicate specimen sent to University of Wyoming); 22294

Cyphelium lucidum (Th. Fr.) Th. Fr.

Growth form: Crustose
Substrate: Lignum
Site(s): Big Sandy Lake Trail; Trail to Deep Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22116; 22209 (duplicate specimen sent to University of Wyoming)

Dermatocarpon intestiniforme (Körber) Hasse

Growth form: Foliose
Substrate: Rock
Site(s): Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake; vicinity of Seneca Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22383; 22210; 22296; 22257; 22262

Dermatocarpon luridum (With.) Laundon

Growth form: Foliose, umbilicate
Substrate: Rock (submerged in water)
Site(s): Waterfall north of Hobb's Lake; Seneca Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22298; 22258 (duplicate specimen sent to University of Wyoming)

Dermatocarpon miniatum (L.) Mann

Growth form: Foliose, umbilicate
Substrate: Rock
Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake; Seneca Lake Trail
Relative abundance: Locally common to abundant
Pollution sensitivity: Unknown
Comments: Material of this species from Big Sandy Lake Trail was collected for elemental analyses.
Deposition of specimens: BYU Herbarium #22117 (duplicate specimen sent to University of Wyoming); 22295; 22259; 22260

Dermatocarpon reticulatum Magnusson

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake;
Seneca Lake Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22118; 22211; 22297; 22261

Dermatocarpon rivulorum (Arnold) Dalla Torre & Sarnth.

Growth form: Foliose, umbilicate

Substrate: Rocks (submerged in water)

Site(s): Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22263 (duplicate specimen sent
to University of Wyoming)

Dimelaena oreina (Ach.) Norman

Growth form: Crustose with effigurate margins

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22119; 22299 (duplicate
specimen sent to University of Wyoming)

Diploschistes scruposus (Schreber) Norman

Growth form: Crustose

Substrate: Rock

Site(s): Hobb's Lake; Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22300 (duplicate sent
to University of Wyoming); 22264

Endocarpon pusillum Hedwig

Growth form: Squamulose
Substrate: Soil
Site(s): Upper Seneca Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22265

Endocarpon tortuosum Herre

Growth form: Crustose to squamulose
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22120

Lecanora argopholis (Ach.) Ach.

Growth form: Crustose
Substrate: Rock
Site(s): Trail to Deep Lake; Trail to Hobb's Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22212; 22302

Lecanora cenisia Ach.

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail; Trail to Deep Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22121; 22213

Lecanora meridionalis Magnusson

Growth form: Crustose
Substrate: Lignum
Site(s): Trail to Deep Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22214 (duplicate specimen sent to University of Wyoming)

Lecanora mughicola Nyl.

Growth form: Crustose
Substrate: Lignum
Site(s): Trail to Deep Lake
Relative abundance: Rare to Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22219 (duplicate specimen sent to University of Wyoming)

Lecanora muralis (Schreber) Rabenh.

Growth form: Crustose with strongly effigurate margins
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Locally common
Pollution sensitivity: Tolerant of sulfur dioxide
Comments: None
Deposition of specimens: BYU Herbarium #22130

Lecanora novomexicana Magnusson *non* (B. de Lesd.) Zahlbr.

Growth form: Crustose with effigurate margins
Substrate: Rock
Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Big Sandy Lake Trail; Trail to Hobb's Lake
Relative abundance: Common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22122; #22128 (duplicate specimen to University of Wyoming); 22215; 22303

Lecanora polytropa (Hoffm.) Rabenh.

Growth form: Crustose
Substrate: Rock
Site(s): Trail to Hobb's Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22304

Lecanora rupicola L. Zahlbr.

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Deep Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22123 (duplicate specimen sent to University of Wyoming); 22216 (duplicate specimen sent to University of Wyoming)

Lecanora saligna (Schrader) Zahlbr.

Growth form: Crustose

Substrate: Lignum

Site(s): Trail to Deep Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Wetmore 1987)

Comments: None

Deposition of specimens: BYU Herbarium #22217

Lecanora symmicta (Ach.) Ach.

Growth form: Crustose

Substrate: Lignum

Site(s): Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22218 (duplicate specimen sent to University of Wyoming); 22305

Lecanora varia (Hoffm.) Ach.

Growth form: Crustose

Substrate: Lignum; conifer bark, twigs

Site(s): Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22220 (duplicate specimen sent to University of Wyoming); 22307; 22308

Lecidea atrobrunnea (Ramond *in* Lam. & DC.) Schaerer

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail; rocky outcrop above Big Sandy
Lake Trailhead; Trail to Hobb's Lake

Relative abundance: Common to abundant

Pollution sensitivity: Tolerant of sulfur dioxide (Ryan 1990)

Comments: This genus (Lecidea) is in desperate need of revision. L. atrobrunnea shows a great deal of variability in thallus color, which may at least in some measure be related to light intensity.

Deposition of specimens: BYU Herbarium #22131; 22132; 22133; 22310
(duplicate specimen sent to University of Wyoming); 22311

Lecidea auriculata Th. Fr.

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail; rocky outcrop above Big Sandy
Lake Trailhead

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: This species may consist of apothecia only, with only scant development of the thallus.

Deposition of specimens: BYU Herbarium #22134; 22135

Lecidea leucothallina Arnold

Growth form: Crustose

Substrate: Rock

Site(s): Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22312

Lecidea saxosa R. Anderson *ineditus*

Growth form: Crustose

Substrate: Rock

Site(s): Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22313

Lecidea tessellata Flörke

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake
Relative abundance: Common to abundant
Pollution sensitivity: Tolerant of sulfur dioxide (Ryan 1990)
Comments: This species represents one of the more common saxicolous lichens collected in the Bridger Wilderness Area.
Deposition of specimens: BYU Herbarium #22136; 22314 (duplicate specimen sent to University of Wyoming)

Lecidea turgidula Fr.

Growth form: Crustose
Substrate: Lignum
Site(s): Trail to Deep Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22221 (duplicate specimen sent to University of Wyoming); 22315

Lecidella carpathica Körber

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail; Trail to Deep Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22137; 22222

Lecidella euphorea (Flörke) Hertel

Growth form: Crustose
Substrate: Lignum
Site(s): Vicinity of Big Sandy Lake; Trail to Deep Lake; Trail to Hobb's Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22138; 22223; 22316

Lecidella stigmatea (Ach.) Hertel & Leuck.

Growth form: Crustose
Substrate: Rocks
Site(s): Big Sandy Lake Trail
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22139

Leprocaulon albicans (Th. Fr.) Nyl. ex Hue

Growth form: Minutely fruticose
Substrate: Moss over rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22141 (duplicate specimen sent to University of Wyoming)

Leproloma membranaceum (Dickson) Vainio

Growth form: Crustose (leprose)
Substrate: Moss over rock
Site(s): Big Sandy Lake Trail; Trail to Deep Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Tolerant of sulfur dioxide (Ryan 1990)
Comments: None
Deposition of specimens: BYU Herbarium #22140; 22224

Leproloma vouauxii (Hue) Laundon

Growth form: Crustose (leprose)
Substrate: Soil; rock
Site(s): Trail to Hobb's Lake; Hobb's Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22317 (duplicate specimen sent to University of Wyoming); 22318

Leptochidium albociliatum (Desmaz.) M. Choisy

Growth form: Foliose

Substrate: Soil/moss over rock

Site(s): Trail to Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to intermediate sensitivity to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22320 (duplicate specimen sent to University of Wyoming)

Letharia vulpina (L.) Hue

Growth form: Fruticose

Substrate: Lignum, conifer bark

Site(s): Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Common to abundant

Pollution sensitivity: Tolerant of sulfur dioxide (Ryan 1990); tolerant to intermediate sensitivity to ozone (Ryan 1990)

Comments: This species represents one of the most common corticolous lichen species collected in the Bridger Wilderness Area. Material of this species from Hobb's Lake, Trail to Hobb's Lake and Big Sandy Lake was collected for elemental analyses.

Deposition of specimens: BYU Herbarium #22142; 22225; 22321

Melanelia disjuncta (Erichsen) Essl.

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake; Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22143 (duplicate specimen sent to University of Wyoming); 22322 (duplicate specimen sent to University of Wyoming); 22323 (duplicate specimen sent to University of Wyoming)

Melanelia elegantula (Zahlbr.) Essl.

Growth form: Foliose

Substrate: Rock; lignum; spruce twigs

Site(s): Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Tolerant of ozone

Comments: None

Deposition of specimens: BYU Herbarium #22144 (duplicate specimen sent to University of Wyoming); 22227 (lignum); 22324 (duplicate specimen sent to University of Wyoming)

Melanelia exasperatula (Nyl.) Essl.

Growth form: Foliose

Substrate: Lignum

Site(s): Big Sandy Lake Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22145 (duplicate specimen sent to University of Wyoming)

Melanelia sorediata (Ach.) Goward & Ahti

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Hobb's Lake

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22155 (duplicate specimen sent to University of Wyoming); 22325

Melanelia subelegantula (Essl.) Essl.

Growth form: Foliose

Substrate: Lignum; conifer bark

Site(s): Trail to Deep Lake; Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22228; 22326; 22327

Mycocalicium subtile (Pers.) Szat.

Growth form: Scant to endoxylic

Substrate: Lignum

Site(s): Big Sandy Lake Trail; Trail to Deep Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: This species is non-lichenized; however, because it is traditionally lumped with the lichens it is included in this list.

Deposition of specimens: BYU Herbarium #22146 (duplicate specimen sent to University of Wyoming); 22229 (duplicate specimen sent to University of Wyoming); 22230

Ochrolechia androgyna (Hoffm.) Arnold

Growth form: Crustose
Substrate: Lignum; decomposing lignum
Site(s): Trail to Deep Lake; Trail to Hobb's Lake
Relative abundance: Rare to locally abundant
Pollution sensitivity: Sensitive to sulfur dioxide (Wetmore 1987)
Comments: None
Deposition of specimens: BYU Herbarium #22196; 22328 (duplicate specimen sent to University Wyoming)

Pannaria conoplea (Ach.) Bory

Growth form: Squamulose
Substrate: Soil/moss over rock
Site(s): Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22329

Pannaria leucophaea (Vahl) P. Jørg.

Growth form: Crustose to minutely foliose
Substrate: Rock
Site(s): Seneca Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22267

Pannaria pezizoides (Weber) Trevisan

Growth form: Squamulose
Substrate: Soil
Site(s): Trail to Hobb's Lake
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: This species is commonly collected along trails in coniferous forests.
Deposition of specimens: BYU Herbarium #22330 (duplicate specimen sent to University of Wyoming)

Parmeliella praetermissa (Nyl. *in* Chyd. & Furuhj.) P. James

Growth form: Squamulose

Substrate: Soil/moss over rock

Site(s): Hobb's Lake; Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22331 (duplicate specimen sent to University of Wyoming); 22268

Parmeliopsis ambigua (Wulfen *in* Jacq.) Nyl.

Growth form: Foliose

Substrate: Conifer bark; lignum

Site(s): Vicinity of Big Sandy Lake; Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Common to abundant

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Wetmore 1987); tolerant of fluoride (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22147; 22231; 22232 (duplicate specimen sent to University of Wyoming); 22332 (duplicate specimen sent to University of Wyoming); 22333

Parmeliopsis hyperopta (Ach.) Arnold

Growth form: Foliose

Substrate: Conifer bark

Site(s): Trail to Deep Lake; Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide (Wetmore 1987)

Comments: None

Deposition of specimens: BYU Herbarium #22233 (duplicate sent to University of Wyoming); 22334

Peltigera canina (L.) Willd.

Growth form: Foliose

Substrate: Soil

Site(s): Deep Lake

Relative abundance: Locally common to abundant

Pollution sensitivity: Tolerant of sulfur dioxide (Ryan 1990); sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22234 (duplicate sent to University of Wyoming)

Peltigera didactyla (With.) Laundon

Growth form: Foliose

Substrate: Soil/moss

Site(s): Vicinity of Big Sandy Lake Trailhead; Trail to Deep Lake; Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22148 (duplicate specimen sent to University of Wyoming); 22235; 22335

Peltigera malacea (Ach.) Funck

Growth form: Foliose

Substrate: Soil

Site(s): Vicinity of Big Sandy Lake Trailhead

Relative abundance: Common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22149 (duplicate specimen sent to University of Wyoming)

Peltigera polydactyla (Necker) Hoffm.

Growth form: Foliose

Substrate: Soil/moss

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22150

Peltigera rufescens (Weis) Humb.

Growth form: Foliose

Substrate: Soil; soil over rocks

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22151 (duplicate specimen sent to University of Wyoming); 22336 (duplicate specimen sent to University of Wyoming); 22337

Peltigera venosa (L.) Hoffm.

Growth form: Foliose

Substrate: Soil

Site(s): Vicinity of Barbara Lake, along trail to Seneca Lake; Trail to Deep Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: This species commonly occurs along road cuts and trails.

Deposition of specimens: BYU Herbarium # 22075 (duplicate specimen sent to University of Wyoming.; 22236

Phaeophyscia ciliata (Hoffm.) Moberg

Growth form: Foliose

Substrate: Rocks

Site(s): Hobb's Lake; Trail to Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22338; 22339

Phaeophyscia endococcina (Körber) Moberg

Growth form: Foliose

Substrate: Rocks

Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Big Sandy Lake Trail; Trail to Hobb's Lake; Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22153; 22237; 22340; 22343

Phaeophyscia nigricans (Florke) Moberg

Growth form: Foliose

Substrate: Rocks

Site(s): Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Intermediate sensitivity to tolerant of sulfur dioxide (Wetmore 1987)

Comments: None

Deposition of specimens: BYU Herbarium #22344

Phaeophyscia sciastra (Ach.) Moberg

Growth form: Foliose

Substrate: Moss, among lichens over rock

Site(s): Rocky outcrop above Big Sandy Lake Trailhead

Relative abundance: Rare

Pollution sensitivity: Sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22152

Physcia caesia (Hoffm.) Fűrnr.

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Deep Lake

Relative abundance: Common

Pollution sensitivity: Intermediate sensitivity to sulfur dioxide

Comments: None

Deposition of specimens: BYU Herbarium #22154 (duplicate specimen sent to University of Wyoming); 22238 (duplicate specimen sent to University of Wyoming); 22342 (duplicate specimen sent to University of Wyoming)

Physcia cascadenis Magnusson

Growth form: Foliose

Substrate: Rock

Site(s): Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22345

Physcia dubia (Hoffm.) Lettau

Growth form: Foliose

Substrate: Moss over rock; conifer bark; rock; lignum

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake; Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Tolerant of sulfur dioxide (Wetmore 1987); sensitive to intermediate sensitivity to Fluoride (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22156; 22341; 22346; 22347; 22348

Physcia phaea (Tuck.) Thomson

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Rocky outcrop above Big Sandy Lake
Trailhead; Hobb's Lake; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22157 (duplicate specimen sent to University of Wyoming); 22129; 22349; 22350 (duplicate specimen sent to University of Wyoming)

Physcia teretiuscula (Ach.) Lynge

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22158

Physconia grisea (Lam.) Poelt

Growth form: Foliose

Substrate: Moss over rock

Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Deep Lake Trail

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22159 (duplicate sent to University of Wyoming); 22240

Physconia muscigena (Ach.) Poelt

Growth form: Foliose

Substrate: Moss over rock

Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Deep Lake Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22160; 22241 (duplicate specimen sent to University of Wyoming)

Physconia perisidiosa (Erichsen) Moberg

Growth form: Foliose

Substrate: Moss

Site(s): Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22242; 22351

Physma sp.

Growth form: Foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22162

Polychidium muscicola (Swartz) Gray

Growth form: Minutely fruticose

Substrate: Soil/moss over rock

Site(s): Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22352 (duplicate specimen sent to University of Wyoming)

Porocyphus coccodes (Flotow) Körber

Growth form: Crustose

Substrate: Rocks

Site(s): Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22353 (duplicate specimen sent to University of Wyoming)

Protoparmelia badia (Hoffm) Hafellner

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22164

Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw.

Growth form: Fruticose

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Intermediate sensitivity to ozone

Comments: None

Deposition of specimens: BYU Herbarium #22165; 22354 (duplicate specimen to University of Wyoming)

Psora luridella (Tuck.) Fink

Growth form: Squamulose

Substrate: Soil

Site(s): Big Sandy Lake Trail

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22166 (duplicate specimen sent to University of Wyoming); 22167

Psora montana Timdal

Growth form: Squamulose

Substrate: Soil

Site(s): Trail to Hobb's Lake, Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22355; 22356 (duplicate specimen sent to University of Wyoming)

Psoroma tenue Henssen var. boreale Henssen

Growth form: Squamulose

Substrate: Moss/soil

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22243

Rhizocarpon badioatrum (Flörke ex Sprengel) Th. Fr.

Growth form: Crustose
Substrate: Rock
Site(s): Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22357

Rhizocarpon disporum (Naeg. ex Hepp) Müll. Arg.

Growth form: Crustose
Substrate: Rock
Site(s): Vicinity of Big Sandy Lake; Hobb's Lake
Relative abundance: Common to abundant
Pollution sensitivity: Unknown
Comments: This species is one of the most common saxicolous lichens collected in the Bridger Wilderness Area.
Deposition of specimens: BYU Herbarium #22168 (duplicate specimen sent to University of Wyoming); 22358

Rhizocarpon ferax Magnusson

Growth form: Crustose
Substrate: Rock
Site(s): Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #21585

Rhizocarpon geminatum Körber

Growth form: Crustose
Substrate: Rock
Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Trail to Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22170; 22359 (duplicate specimen sent to University of Wyoming)

Rhizocarpon geographicum (L.) DC.

Growth form: Crustose

Substrate: Rock

Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake; Seneca Lake Trail

Relative abundance: Common to abundant

Pollution sensitivity: Tolerant of sulfur dioxide (Ryan 1990); sensitive to fluoride (Ryan 1990)

Comments: This species is probably the most common saxicolous lichen collected in the Bridger Wilderness Area.

Deposition of specimens: BYU Herbarium #21577 (duplicate specimen sent to University of Wyoming); 21578 (duplicate specimen sent to University of Wyoming); 22244; 21593 (duplicate specimen sent to University of Wyoming); 21592; 21576

Rhizocarpon grande (Flörke ex Flotow) Arnold

Growth form: Crustose

Substrate: Rock

Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Big Sandy Lake Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22173; 22174

Rhizocarpon lavatum (Ach. ex Fr.) Hazslin.

Growth form: Crustose

Substrate: Rock (submerged in water)

Site(s): Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #21575

Rhizocarpon lindsayanum Räsänen ssp. kittilense

Growth form: Crustose

Substrate: Rock

Site(s): Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #21586

Rhizocarpon renneri Poelt

Growth form: Crustose
Substrate: Rock
Site(s): Trail to Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22360

Rhizocarpon sublucidum Räsänen

Growth form: Crustose
Substrate: Rock
Site(s): Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #21584

Rhizocarpon tinei Torn. ssp. vulgare

Growth form: Crustose
Substrate: Rock
Site(s): Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: Extensive monographic work on the North American members of the genus *Rhizocarpon* is needed. The nomenclature currently in use is based largely on European descriptions from the mid 1950s. According to the European literature this species is a new record for North America.
Deposition of specimens: BYU Herbarium #21588; 21589 (duplicate specimen sent to University of Wyoming)

Rhizoplaca chrysoleuca (Sm.) Zopf

Growth form: Foliose, umbilicate
Substrate: Rock
Site(s): Trail to Deep Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: Material of this species from Big Sandy Lake was collected for elemental analyses.
Deposition of specimens: BYU Herbarium #22245 (duplicate specimen sent to University of Wyoming)

Rhizoplaca melanophthalma (DC. in Lam. & DC.) Leuck. & Poelt

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Along Emigrant Trail; Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Common-abundant

Pollution sensitivity: Sensitive to sulfur dioxide (Hale, 1982)

Comments: Material collected at the Emigrant Trail site has an unusual morphology and thallus color.

Deposition of specimens: BYU Herbarium #22077; 22246 (duplicate specimen sent to University of Wyoming); 22364

Rhizoplaca subdiscrepans (Nyl.) R. Sant

Growth form: Foliose, closely adnate to substrate

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22175; 22365 (duplicate specimen sent to University of Wyoming)

Rinodina mniaraea (Ach.) Körber

Growth form: Crustose

Substrate: Soil/detritus; moss

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake; Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22178; 22361; 22362 (duplicate specimen sent to University of Wyoming)

Rinodina mniareae (Ach.) Körber var. mniaroeiza (Nyl.) H. Magn.

Growth form: Crustose

Substrate: Soil/detritus

Site(s): Big Sandy Lake Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22179 (duplicate specimen sent to University of Wyoming)

Rinodina obnascens (Nyl.) Oliv.

Growth form: Crustose
Substrate: Rock
Site(s): Hobb's Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22363

Rinodina pyrina (Ach.) Arnold

Growth form: Crustose
Substrate: Lignum
Site(s): Vicinity of Big Sandy Lake
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22180

Solorina crocea (L.) Ach.

Growth form: Foliose
Substrate: Soil
Site(s): Vicinity of Barbara Lake, along Seneca Lake Trail; Near Hobb's Lake
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: This species occurs commonly along road cuts and trails.
Deposition of specimens: BYU Herbarium #22076 (duplicate specimen sent to University of Wyoming; 22365 (duplicate specimen sent to University of Wyoming)

Sporastatia testudinea (Ach.) Massal.

Growth form: Crustose
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22181

Staurothele areolata Lettau

Growth form: Crustose

Substrate: Rock

Site(s): Big Sandy Lake Trail

Relative abundance: Common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22182 (duplicate specimen sent to University of Wyoming)

Staurothele clopimoides (Arnold) Steiner

Growth form: Crustose

Substrate: Rock

Site(s): North of Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22367

Staurothele fissa (Taylor) Zwackh

Growth form: Crustose

Substrate: Rock

Site(s): North of Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22368

Stereocaulon glareosum (Savicz) Magnusson

Growth form: Minutely fruticose

Substrate: Soil

Site(s): Big Sandy Lake Trail; Seneca Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22183; 22269 (duplicate specimen sent to University of Wyoming)

Stereocaulon rivulorum Magnusson

Growth form: Fruticose

Substrate: Soil

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22184 (duplicate specimen sent to University of Wyoming); 22369

Trapeliopsis granulosa (Hoffm.) Lumbsch.

Growth form: Crustose

Substrate: Lignum

Site(s): Trail to Hobb's Lake

Relative abundance: Rare to locally abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22370

Umbilicaria decussata (Vill.) Zahlbr.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Vicinity of Big Sandy Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22185 (duplicate specimen sent to University of Wyoming)

Umbilicaria deusta (L.) Baumg.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22371

Umbilicaria hyperborea (Ach.) Hoffm.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Big Sandy Lake Trail; Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22186 (duplicate specimen sent to University of Wyoming); 22372 (duplicate specimen sent to University of Wyoming)

Umbilicaria vellea (L.) Ach.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Rocky outcrop at Big Sandy Lake Trailhead; Big Sandy Lake Trail; Trail to Hobb's Lake; Vicinity of Seneca Lake

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: Material of this species from Hobb's Lake and Big Sandy Lake was collected for elemental analyses.

Deposition of specimens: BYU Herbarium #22187 (duplicate specimen sent to University of Wyoming); 22169 (duplicate specimen sent to University of Wyoming); 22188; 22373; 22271

Umbilicaria virginis Schaerer

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Big Sandy Lake Trail; Seneca Lake Trail

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22189 (duplicate specimen sent to University of Wyoming); 22248 (duplicate sent to University of Wyoming); 22270

Usnea hirta (L.) Weber *ex* Wigg.

Growth form: Fruticose

Substrate: Lignum; conifer bark

Site(s): Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Rare

Pollution sensitivity: Sensitive to intermediate sensitivity to sulfur dioxide (Wetmore 1987)

Comments: None

Deposition of specimens: BYU Herbarium #22249; 22374; 22375

Usnea lapponica Vainio

Growth form: Fruticose
Substrate: Conifer twigs
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22190

Xanthoparmelia cumberlandia (Gyelnik) Hale

Growth form: Foliose
Substrate: Rock
Site(s): Rocky outcrop above Big Sandy Lake Trailhead; Trail to Hobb's Lake; Hobb's Lake
Relative abundance: Locally common to abundant
Pollution sensitivity: Sensitive to sulfur dioxide (Ryan 1990)
Comments: Material of this species from Hobb's Lake, Trail to Hobb's Lake, Big Sandy Lake, Trail to Big Sandy Lake and Seneca Lake was collected for elemental analyses.
Deposition of specimens: BYU Herbarium #22191 (duplicate specimen sent to University of Wyoming); 22376; 22377

Xanthoria candelaria (L.) Th. Fr.

Growth form: Minutely foliose
Substrate: Rock
Site(s): Big Sandy Lake Trail
Relative abundance: Rare
Pollution sensitivity: Sensitive to ozone (Ryan 1990); intermediate sensitivity to tolerant of sulfur dioxide (Ryan 1990)
Comments: None
Deposition of specimens: BYU Herbarium #22192

Xanthoria elegans (Link) Th. Fr.

Growth form: Minutely foliose to minutely fruticose
Substrate: Rock
Site(s): Big Sandy Lake Trail; Trail to Deep Lake; Trail to Hobb's Lake; Hobb's Lake; Seneca Lake Trail
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium #22193 (duplicate sent to University of Wyoming); 22250; 22378 (duplicate specimen sent to University of Wyoming); 22379 (duplicate specimen sent to University of Wyoming); 22272 (duplicate specimen sent to University of Wyoming)

Xanthoria fallax (Hepp *in* Arnold) Arnold

Growth form: Minutely foliose

Substrate: Lignum

Site(s): Trail to Hobb's Lake

Relative abundance: Locally common

Pollution sensitivity: Sensitive to intermediate sensitivity to sulfur dioxide (Wetmore 1987); tolerant of ozone (Ryan 1990); sensitive to nitrous oxides and PAN (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium #22380 (duplicate sent to University of Wyoming)

Xanthoria lobulata (Flörke) B. de Lesd.

Growth form: Crustose to minutely foliose

Substrate: Rock

Site(s): Big Sandy Lake Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22194

Xanthoria soorediata (Vainio) Poelt

Growth form: Minutely foliose

Substrate: Rock

Site(s): Trail to Hobb's Lake; Vicinity of Seneca Lake

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22381; 22273

Xylographa vitiligo (Ach.) Laundon

Growth form: Scant to endoxyllic

Substrate: Lignum

Site(s): Trail to Deep Lake; Trail to Hobb's Lake

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium #22251 (duplicate specimen sent to University of Wyoming); 22382

Observations and Conclusions:

1. The lichen flora of Bridger Wilderness Area is diverse and well developed. From our collections at the six reference sites we have identified a total of 149 species in 54 genera. All growth forms are well represented; however, the flora is dominated by crustose species (48%, 71 species). This is not an

unusual pattern for the Rocky Mountains. Foliose lichens comprised 28% (41 species) of the flora with squamulose species constituting 16% (25 species) and fruticose species 8% (12 species). We estimate that the complete lichen flora for the entire wilderness area consists of between 250 and 300 species. A similar, but much more extensive study in the Uinta Mountains of northeastern Utah resulted in 291 taxa in 95 genera.

2. In the Bridger Wilderness Area lichens were collected from 5 basic substrates: rocks, lignum/bark, moss, soil, and the thalli of other lichen species. The most important substrate in our study was rock. A total of 76 species (51% of the flora) were collected from rock substrates. In Bridger Wilderness Area rock substrates are remarkably homogenous, consisting mainly of granitics. Corticolous substrates (conifer bark and lignum) were second in importance accounting for 35 species (23 % of the flora). Twenty three species (16% of the flora) were collected from the soil with 14 species (9% of the flora) growing over various species of bryophytes. Finally, 2 species (1% of the flora) occurred as epiphytes on other lichen species.
3. High species diversity as well as abundance of all basic growth forms indicates that the lichen communities are generally healthy and for the most part not impacted by air pollutants.
4. In addition, the general absence of necrotic and/or bleached thalli also suggests that the lichen flora has not been particularly impacted by air pollution.
5. The occurrence of several recognized pollution sensitive species from one or more substrates at each reference site also lends support to the conclusion that the lichen communities are relatively healthy.
6. Baseline concentrations of potential pollutant elements were evaluated in 5 different species of lichens collected from the six reference sites. Specifically, *Dermatocarpon miniatum* (rock), *Xanthoparmelia cumberlandia* (rock), *Umbilicaria vellea* (rock), *Letharia vulpina* (conifer lignum), and *Rhizoplaca chrysoleuca* (rock) were analyzed for pollutant accumulation. In Mason Hale's 1985 preliminary report on the use of lichens as biomonitors of air quality in the Bridger Wilderness Area he reported data from 17 samples using 5 species of lichens from two general areas in the wilderness (along Boulder Creek Trail and along the trail to Big Sandy Lake). Two of the sensitive indicator species used in our study (*Xanthoparmelia cumberlandia* and *Letharia vulpina*) were also used by Mason Hale. Furthermore, one of our sensitive indicator species (*Xanthoparmelia cumberlandia*) was collected from one of Hale's general collection areas (along the trail to Big Sandy Lake). Data from our samples along with Hale's 1985 data for *Xanthoparmelia cumberlandia* collected along the trail to Big Sandy Lake are reported in Table 1. In 1985 Hale specifically

expressed concern about elevated lead levels in some of his samples including the *Xanthoparmelia cumberlandia* he collected along the trail to Big Sandy Lake (98.7-106.6 ppm). Our data show that lead levels are still high in samples of this species collected from the same general area (mean of six samples = 145 ppm). Hale also mentioned that zinc (73.8-75.7 ppm in *Xanthoparmelia cumberlandia* from Big Sandy Lake Trail) and manganese (58.1-119.8 ppm in *Xanthoparmelia cumberlandia* from Big Sandy Lake Trail) concentrations were relatively high. Our data show that concentrations of these two elements in samples of *Xanthoparmelia cumberlandia* from Big Sandy Lake Trail are now almost double Hale's 1985 values (mean zinc concentrations = 146 ppm, mean manganese concentrations = 170 ppm). Iron, cobalt, titanium, vanadium, chromium, and strontium concentrations in our samples of *Xanthoparmelia cumberlandia* from Big Sandy Lake Trail were also significantly higher than Hale's 1985 samples from the same site and species. These data show that in at least one species (*Xanthoparmelia cumberlandia*) from Big Sandy Lake Trail accumulation of several important pollutant elements has increased significantly. Some other elements, especially, lead, arsenic and selenium reflect impact from coal-fired power plant emissions and should be specifically monitored in the future. Unfortunately, two of the three (arsenic and selenium) were not evaluated by Hale, therefore, our 1991 data represents the baseline value for these elements. In spite of the fact that thallus concentrations of lead, zinc and manganese in our samples are 2 to 3 times higher than background concentrations for most of the Rocky Mountain Region, overall concentrations for these pollutants are still relatively low compared to more heavily polluted areas where lead concentrations are often between 1000 and 2000 ppm.

7. Generally, sulfur concentrations above .20% in sensitive indicator species indicates significant potential for sulfur-related damage to lichen communities. In our study sulfur values were relatively high in 3 species from three of the reference sites. *Dermatocarpon miniatum* an umbilicate rock lichen collected along the trail to Big Sandy Lake had the highest sulfur values (.49%). However, my experience with this species suggests that it consistently shows extremely high sulfur values, regardless of where it is collected. I am convinced that this species either has a rather remarkable capacity for accumulating and storing airborne sulfur species or perhaps more likely it selectively occupies substrates which are high in sulfur content and has evolved some mechanism for accumulating sulfur from the substrate. Nevertheless, based on my previous experience with this species, confirmed now with our data from the Bridger Wilderness Area, I do not believe that this species provides an accurate picture of sulfur accumulation. However, samples of *Letharia vulpina*, a corticolous/lignicolous fruticose lichen collected at the Big Sandy Lake reference site showed relatively high sulfur values (.20%). Samples of *Xanthoparmelia cumberlandia* from the Hobb's Lake reference site also had

TABLE #1: Concentrations of potential pollutant elements in sensitive indicator species from reference sites in the Bridger Wilderness Area

	Elements (ppm except where indicated)						
	S%	Cl	K%	Ca%	Ti	V	Cr
<i>Dermatocarpon miniatum</i> , Trail to Big Sandy Lake, on rock, Sample #2	.49	305	1.08	0.23	186	6.0	3.0
<i>Xanthoparmelia cumberlandia</i> , Hobb's Lake, on rock, Sample #4	.29	750	1.04	2.07	870	7.1	17.3
<i>Umbilicaria vellea</i> , Hobb's Lake, on rock, Sample#5	.18	450	0.55	0.077	49	3.5	1.84
<i>Letharia vulpina</i> , Hobb's Lake, on pine lignum, Sample #6	.11	330	0.3	0.55	97	3.7	28
<i>Letharia vulpina</i> , Big Sandy Lake, on pine Lignum, Sample#9	.20	310	0.53	1.21	260	6.1	4.5
<i>Rhizoplaca chrysoleuca</i> , Big Sandy Lake, on rock, Sample #10	.11	107	0.44	0.99	380	8.5	5.7
<i>Xanthoparmelia cumberlandia</i> , below Big Sandy Lake, on rock, Sample #13	.13	280	0.73	3.5	1160	30	22
<i>Xanthoparmelia cumberlandia</i> , ledges on N side of Big Sandy Trail, Sample #5 (1985 data)	n.d.	n.d.	0.33	2.20	302	14.3	5.0
<i>Xanthoparmelia cumberlandia</i> , ledges on N side of Big Sandy Trail, Sample #6 (1985 data)	n.d.	n.d.	0.33	2.30	415	17	5.7

TABLE #1: Continued

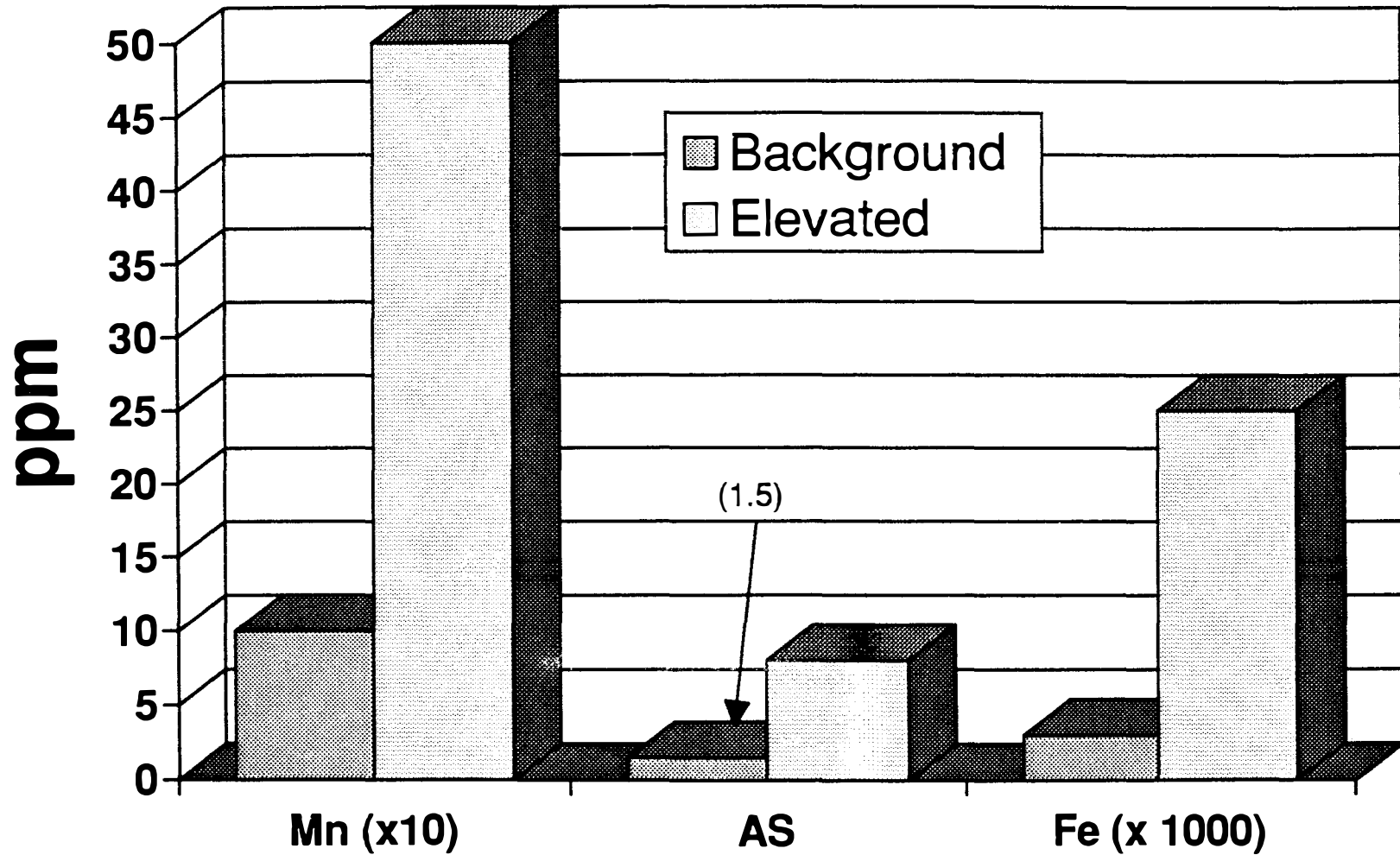
	Elements (ppm except where indicated)						
	Ni	Cu	Zn	Pb	Mn	Fe	Co
<i>Dermatocarpon miniatum</i> , Trail to Big Sandy Lake, on rock, Sample #2	0.42	9.5	59	12.9	182	1630	2.9
<i>Xanthoparmelia cumberlandia</i> , Hobb's Lake on rock, Sample #4	*	21	163	83	137	6500	12
<i>Umbilicaria vellea</i> , Hobb's Lake on rock, Sample #5	1.11	4.7	240	4.8	28	540	0.49
<i>Letharia vulpina</i> , Hobb's Lake on pine lignum, Sample #6	0.52	6.5	33	27	106	500	1.04
<i>Letharia vulpina</i> , Big Sandy Lake on pine lignum, Sample #9	2.8	13	48	47	100	1600	2.0
<i>Rhizoplaca chrysoleuca</i> , Big Sandy Lake on rock, Sample #10	2.2	17.9	39	40	59	2800	8.4
<i>Xanthoparmelia cumberlandia</i> , below Big Sandy Lake, on rock, Sample #13	*	35	146	145	170	8600	25
<i>Xanthoparmelia cumberlandia</i> , ledge on N side of Big Sandy Trail, Sample #5 (1985 data)	5.2	35.4	73.8	106.6	58.1	4362	0.33
<i>Xanthoparmelia cumberlandia</i> , ledge on N side of Big Sandy Trail, Sample #5 (1985 data)	4.5	35.7	75.7	98.7	119.8	4905	0.33

TABLE #1: Continued

	Elements (ppm except where indicated)				
	A s	Se	B r	Rb	Sr
<i>Dermatocarpon miniatum</i> , Trail to Big Sandy Lake, on rock, Sample #2	0.87	0.84	6.7	10.8	33
<i>Xanthoparmelia cumberlandia</i> , Hobb's Lake on rock, Sample #4	4.9	1.93	52	62	90
<i>Umbilicaria vellea</i> , Hobb's Lake on rock, Sample #5	2.6	0.79	6.16	23	9.5
<i>Letharia vulpina</i> , Hobb's Lake on pine lignum, Sample #6	1.21	1.38	9.3	15.7	33
<i>Letharia vulpina</i> , Big Sandy Lake on pine lignum, Sample #9	4.0	1.35	15.6	16	50
<i>Rhizoplaca chrysoleuca</i> , Big Sandy Lake on rock, Sample #10	0.71	0.61	7.9	21	86
<i>Xanthoparmelia cumberlandia</i> , below Big Sandy Lake, on rock, Sample #13	6.8	1.7	53	58	122
<i>Xanthoparmelia cumberlandia</i> , ledge on N side of Big Sandy Trail, Sample #5 (1985 data)	n.d.	n.d.	n.d.	n.d.	26.7
<i>Xanthoparmelia cumberlandia</i> , ledge on N side of Big Sandy Trail, Sample #6 (1985 data)	n.d.	n.d.	n.d.	n.d.	26.4

* below detectable levels

Fig. 2 Lichen Biomonitoring Program and Baseline



Elemental Analysis Data
(background and elevated pollutant levels)

Fig. 2 cont. Lichen Biomonitoring Program and Baseline

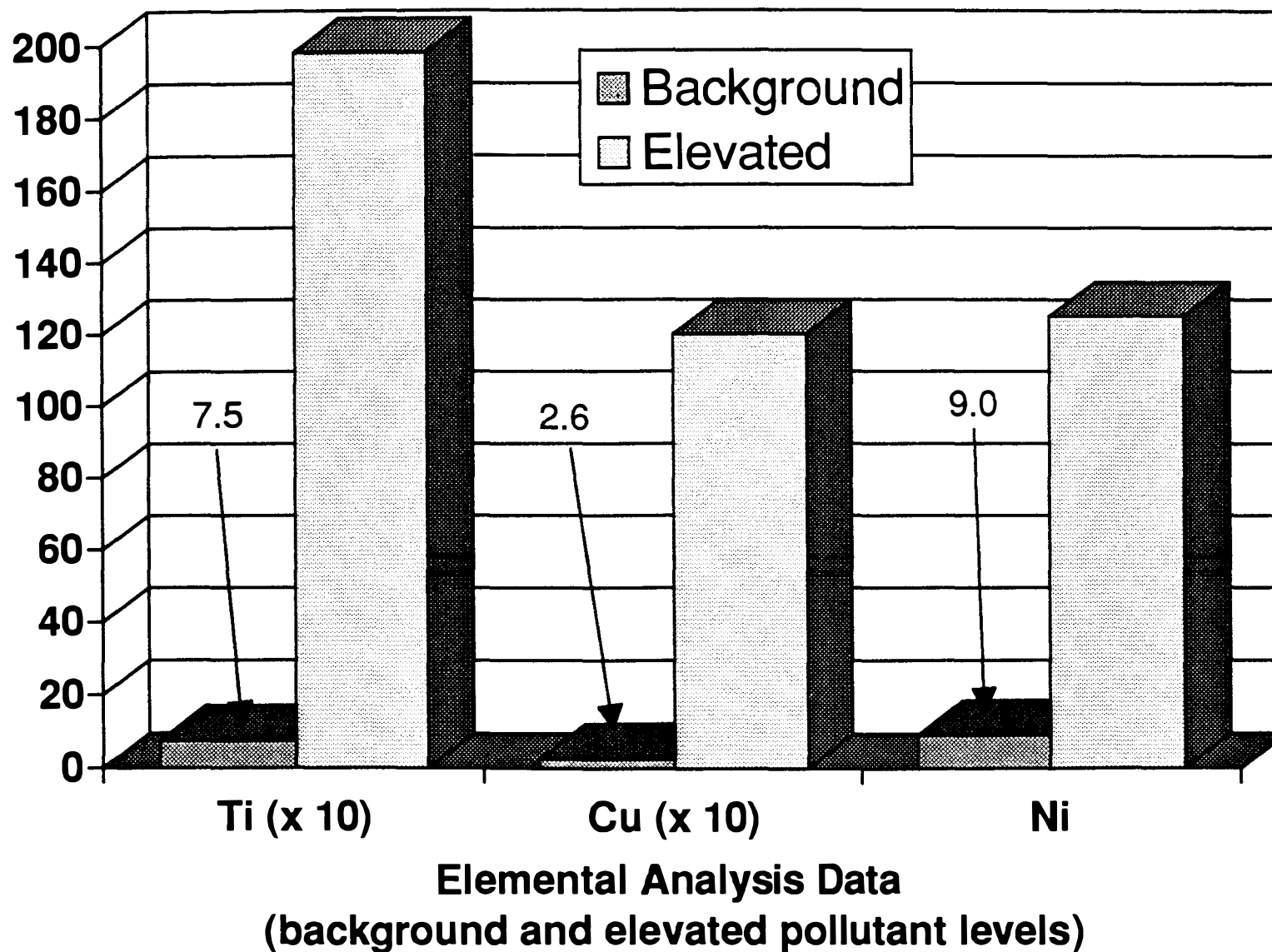
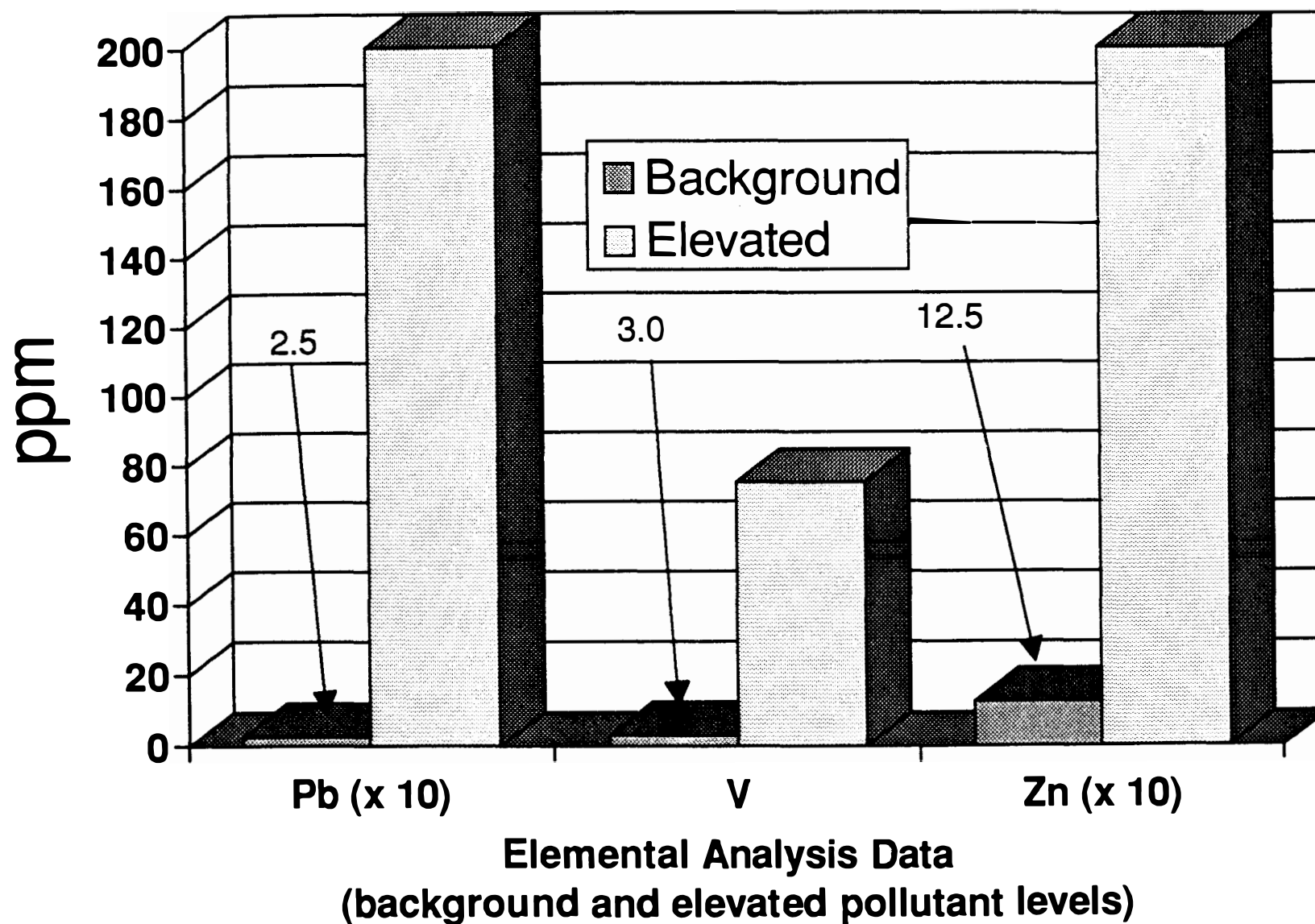


Fig. 2 cont. Lichen Biomonitoring Program and Baseline



high sulfur concentrations (.29%). Samples from these two sites merit careful consideration in future reevaluations of the baseline.

Recommendations:

1. Eventually, additional reference sites should be established in other parts of the wilderness area. This will provide additional information about the flora as well as provide additional baseline information about the status of sensitive indicator species.
2. Elemental analysis of sensitive indicator species should be performed every 5 to 8 years, depending on significant changes in existing pollution patterns or development of new air pollution sources in the general vicinity of the wilderness. Specifically, sulfur, lead, arsenic and selenium concentrations should be carefully monitored in samples of *Xanthoparmelia cumberlandia*, especially from the Big Sandy Lake Trail site.
3. Re-evaluation of the lichen flora at the existing reference sites is generally unnecessary, unless sensitive indicator species begin to show either high levels of problem pollutant elements or significant changes in relative abundance.
4. Eventually, the additional sensitive indicator material should be analyzed in order to strengthen the existing baseline.

BIBLIOGRAPHY

- Duflou, H., W. Maenhaut, and J. DeReuck. 1987. Application of PIXE analysis to the study of regional distribution of trace elements in normal human brain. *Biological Trace Element Research* 13: 1.
- Fields, R.D. and L.L. St. Clair. 1984. A comparison of methods for evaluating SO₂ impact on selected lichen species: *Parmelia chlorochroa*, *Collema polycarpon* and *Lecanora muralis*. *The Bryologist* 87: 297-301.
- Fields, R.D. and L.L. St. Clair. 1984. The effects of SO₂ on photosynthesis and carbohydrate transfer in the two lichens: *Collema polycarpon*, and *Parmelia chlorochroa*. *American Journal of Botany* 71: 986-998.
- Hale, M.E. 1983. *The Biology of Lichens*. pp. 1-190. Arnold Publishers, London.
- Hale, M.E. 1985. Report on use of lichens as air pollution monitors in the Wind River Range, Bridger Wilderness, Bridger-Teton National Forest. U.S. Forest Service Technical Report, 7pp.

- Hale, M.E. 1991. A synopsis of the lichen genus *Xanthoparmelia* (Vainio) Hale (Ascomycotina, Parmeliaceae). Smithsonian Contributions to Botany 74: 1-250.
- Lawrey J.D. and M.E. Hale. 1981. Retrospective study of lichen lead accumulation in the northeastern United States. The Bryologist 84: 449-456.
- Rope, S.K. and L.C. Pearson. 1990. Lichens as air pollution biomonitors in a semiarid environment in Idaho. The Bryologist 85: 185-192.
- Rushforth, S.R., L.L. St. Clair, J.D. Brotherson, and G.T. Nebeker. 1982. Lichen community structure in Zion National Park. The Bryologist 85: 185-192.
- Ryan, B.D., T.H. Nash, and W. Davis. 1990. Lichens and air quality in the Mount Baldy Wilderness Area. U.S. Forest Service Technical Report.
- St. Clair, L.L. 1989. Report concerning establishment of a lichen biomonitoring program for the Jarbidge Wilderness Area, Humboldt National Forest, Nevada. U.S. Forest Service Technical Report. 15 pp.
- Schutte, J.A. 1977. Chromium in two corticolous lichens from Ohio and West Virginia. The Bryologist 80: 279-283.
- Wetmore, C.M. 1987. Lichens and air quality in Saguaro National Monument. Technical report submitted to the National Park Service, CX 0001-2-0034.
- Wetmore, C.M. 1989. Lichens and air quality in Cuyahoga National Recreation Area, Ohio. The Bryologist 92: 273-281.